samples using a continuous laser system on sub-millimeter fragments. We have irradiated and obtained preliminary stepped temperature release data on three samples, and total fusion data on a fourth. *15304,7,* a fine-grained ophitic LKFM melt, was measured in 43 temperature steps. A good 22-step plateau that contains 58% of the $^{39}$Ar released gives an age of 3862 ± 8 Ma (Fig.) that we interpret as the melt crystallization age. *15356,9,* a micropoikilitic melt that is LKFM but different in trace element chemistry from *15304,7* (hence formed in a different event), has a plateau at 3838 ± 8 Ma over 48% of the $^{39}$Ar release that can also be considered a crystallization age. *15308,9* crystallized in, or was affected by, a younger event, with the releases showing ages climbing from about 2.6 Ga to a fusion step at about 2.85 Ga. Its groundmass is very fine-grained, even glassy; its composition is similar to *15356.* Total fusion ages on *15414,3,* which has an unusual chemistry lacking a KREEP component, range from 4053 ± 25 to 4091 ± 27 Ma, but stepped data are required to define its crystallization age.

The ages of the impact melts show no definitive evidence for bombardment prior to 4 Ga ago. They are consistent with the concept of a cataclysmic bombardment in the period 3.9 to 3.8 Ga during which KREEP was first brought to the lunar surface; any older impacts were into KREEP poor terrains. Reference: Ryder G. and Spudis P. (1987) Chemical composition and origin of Apollo 15 impact melts. *Proc. Lunar Planet. Sci. Conf.* **17th,** E432–446.

**Trace element distributions in Allende compact type a inclusions.** Andrew M. Davis,[1] Steven B. Simon[2] and Lawrence Grossman.[1,2] [1]Enrico Fermi Institute, [2]Department of the Geophysical Sciences, University of Chicago, Chicago, IL 60637, USA.

Compact Type A refractory inclusions (CTA's) in C3V chondrites are 0.5–1 cm diameter, rounded objects consisting largely of mm-sized melilite (Åk$_{6\text{-}60}$) crystals that poikilitically enclose abundant spinel. Very minor amounts of fassaite, perovskite and, rarely, rhönite are usually found on grain boundaries between melilite crystals. Teshima and Wasserburg (1) suggested that CTA's crystallized from melts, but have been extensively recrystallized by subsequent heating. We have studied four CTA's by electron and ion microprobe.

Three inclusions, TS2, TS32 and A37, have normal petrographic characteristics for CTA's, whereas in TS68, fassaite occurs poikilitically enclosed in melilite as well as at melilite grain boundaries.

Bulk REE patterns of the CTA's were reconstructed from ion microprobe analyses of individual phases. TS2 has a modified group II REE pattern, with relatively uniform enrichments of light REE (LREE), Eu, Tm and Yb and 4-6-fold depletions in the remaining heavy REE (HREE) and Y compared to LREE. The other three inclusions have group I REE patterns, characterized by uniform enrichments in REE and Y.

Fassaite and melilite in TS68 have REE patterns similar to those found in the same phases in Type B1 inclusions: melilite has uniform enrichments of 5–20 × C1 for LREE, a positive Eu anomaly (30 × C1) and HREE enrichments that fall from 5–20 × C1 for Gd to 2–8 × C1 for Lu; fassaite LREE enrichments increase from 10–20 × C1 for La to 25–50 × C1 for Sm, Eu is at 7 × C1 and the HREE have uniform enrichments of 50–100 × C1. Perovskite has LREE enrichments that increase from 350 to 400 × C1 from La to Sm, a negative Eu anomaly (100 × C1) and HREE enrichments that fall from 450 to 300 × C1 from Gd to Lu.

In TS32, melilite has uniform REE enrichments of 4–12 × C1, with a positive Eu anomaly (28 × C1). Fassaite has LREE enrichments that increase from 3 × C1 for La to 10 × C1 for Sm, a negative Eu anomaly (5 × C1) and HREE enrichments that steadily increase from 10 to 140 × C1 from Gd to Lu. In TS32 perovskite, enrichments fall from 2300 to 800 × C1 from La to Lu and there is a negative Eu anomaly (130 × C1). The REE distribution between melilite, fassaite and perovskite in A37 and TS2 is similar to that in TS32, except that, in A37, fassaite is not as steeply fractionated and, in TS2, all phases have the modified group II pattern of the bulk inclusion overprinted on their REE patterns.

If CTA's crystallized from a melt and have not been recrystallized, trace element distributions among phases should be controlled by normal fractional crystallization. In contrast, metamorphic recrystallization should cause trace element distributions to be controlled by equilibrium solid-solid partitioning. The highly fractionated HREE patterns of fassaite would not be expected from solid-solid partitioning. On the other hand, since melilite/liquid partition coefficients fall steadily from Sm to Y to Yb for all melilite (2), any fassaite that crystallized from late-stage liquids resulting from extensive melilite crystallization would be expected to have strongly fractionated HREE. Petrography indeed indicates that fassaite crystallized after 98% melilite + spinel crystallization in TS2 and TS32, but fassaite formed earlier in TS68, accounting for the less fractionated HREE in the latter. If metamorphic recrystallization of CTA's occurred, it did not affect trace element distributions. References: (1) Teshima J. and Wasserburg G. J. (1985) *LPS* **16,** 855–856. (2) Kuehner S. M. *et al.* (1989) *GCA* **53,** 3115–3130.

**Dynamic crsytallization experiments and cathodoluminescence studies of type I chondrule compositions.** John M. DeHart and Gary E. Lofgren. Mail Code SN2, Johnson Space Center, Houston, TX 77058, USA.

*Introduction.* Type I chondrules in the least altered Type 3 ordinary chondrites have both chemical (1) and cathodolumescence (CL) properties (2) that are probably related to the conditions of their formation. The Fe-poor olivines and pyroxenes found in these chondrules most often emit red CL, although occasional grains that emit blue CL have also been noted (2, 3). The refractory mesostases that enclose these grains emit yellow CL in chondrules found in meteorites of the lowest petrologic type (Semarkona and Bishunpur, types 3.0), but emit blue CL in meteorites of higher type. These differences in the CL properties of type I chondrule mesostases are believed to be due to physical changes in either composition or structure caused by the effects of low level thermal metamorphism (4). In order to explore the conditions of formation and alteration of the yellow luminescing mesostases and minor element partitioning between crystals and liquids in type I chondrules, we are conducting a two-stage series of experiments. First, we will explore the conditions of formation for this yellow phosphor with dynamic crystallization experiments using a composition (CH-6) similar to the average type I chondrule composition reported in (1). Second, experimentally produced charges that possess yellow luminescing glass will be annealed for fixed tmes and temperatures to determine the conditions that cause the yellow phosphor to change its CL properties.

*Experimental.* Standard gas-mixing and dynamic crystallization techniques were used (5). The liquidus temperature of the CH-6 composition is 1555 °C. Two series of subliquidus experiments have been completed. Both series consisted of experiments that were melted at 1540 °C for 1 hour at an oxygen fugacity 0.8 log units below the Iron-Wustite buffer and were quenched in air at temperatures ranging from 1350 to 1000 °C. The first series of experiments were cooled at 10 °C per hour and the second series were cooled at 100 °C per hour. Two experiments in the 10 °C per hour series were annealed at 1050 °C and 1000 °C for 1 and 19 hours, respectively, prior to quenching in air. CL photographs were made using a Nuclide Luminoscope attached to a Zeiss Photoscope.

*Results.* Glass produced by quenching from the experimental liquidus was nonluminescent. All experiments quenched above 1050 °C in the 10 °C per hour series of experiments produced glasses that emitted a dull yellow CL. Both experiments that were annealed at 1050 °C and 1000 °C for 1 and 19 hours, respectively, had glasses that emitted bright yellow CL, while the experiment that was cooled at the same rate and quenched at 1000 °C had only patches of glass with bright yellow CL around the outer perimeter of the charge. The experiments that were cooled at 100 °C per hour contained less glass that emitted yellow CL. The experiment quenched at 1050 °C in this series possessed bright yellow CL from a few isolated regions of glass, and the experiments quenched at 1150 °C and 1000 °C had small areas surrounding the platinum hangwire where the glasses emitted bright yellow CL. The remaining glass in all three charges was nonluminescent.

*Conclusion.* These preliminary results indicate the phosphor emitting yellow CL is formed by the fractionation processes that occur during crystallization. The phase responsible for yellow CL is easily formed from melts that experienced slow cooling rates and/or isothermal annealing periods during their cooling history. Faster cooling rates appear to inhibit the phosphor's formation. References: (1) Jones R. H. and Scott E. R. D. (1989) *Proc. LPSC* **19,** 523–536. (2) DeHart J. M., Lofgren G. E. and Sears D. W. G. (1987) *LPSC* **18,** 225–226. (3) Steele I. M. (1986) *GCA* **50,** 1379–1395. (4) DeHart J. M. (1989) Ph.D. thesis, University of Arkansas. (5) Lofgren and Russell (1986) *GCA* **50,** 715–726.